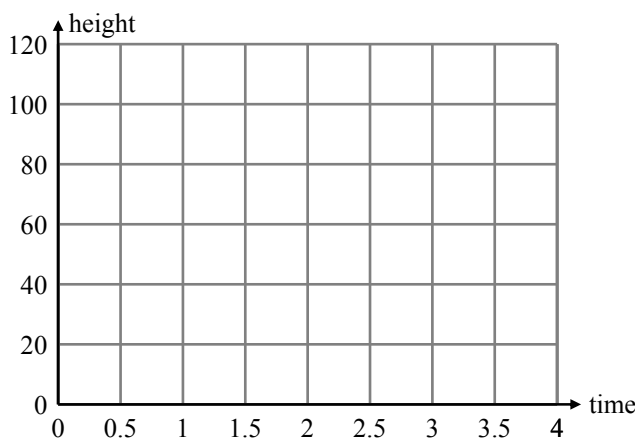


**Directions:** The purpose of this task is for you to explore the relationship between average and instantaneous velocity. The situation you will explore is that of the position and velocity of a ball thrown into the air, and how the position and velocity change over time. You will explore the different representations for the position of the ball, and how these representations can be used to learn more about the average and instantaneous velocity of the ball. When you are finished, you will present your solutions to your classmates and explain your answers to the reflection questions at the end.

1. Imagine that you throw a ball into the air and record the ball's height as a function of time.

Time (sec)	0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5
Height (ft)	5.0	38.5	64.0	81.5	91.0	92.5	86.0	71.5	49.0	18.5

- a. Find the average velocity of the book between 0.5 and 1.5 seconds. What does the sign of the velocity tell you about the book?
- b. At time  $t = 3.5$  seconds, does the book appear to be going up or coming down? How can you tell?
- c. The equation that fits the data in the table is  $s(t) = at^2 + bt + c$ . Use the points corresponding to  $t = 0$ , 1, and 2 to find the values of  $a$ ,  $b$ , and  $c$ .
- d. Provide a graphical representation of your answer in part c. In addition, show the secant line that represents the average velocity you found in part a.



2. Using the equation you found in part 1c, answer the following questions:
- What symbol would you use to represent the change in time? What about the change in height? What about the average velocity?
  - Find the average velocity of the book for the following time intervals. Be sure to use correct symbols
    - $[1.0, 1.5]$
    - $[1.0, 1.1]$
    - $[1.0, 1.01]$
    - $[1.0, 1.001]$
  - Using your answers to part b, estimate the *instantaneous* velocity for the book at time  $t = 1$  second. Based on your answer, is the book rising or falling at this time? Explain how you know.
  - Using the rules of derivatives we learned last week, find the equation for the instantaneous velocity (the derivative of  $s$  with respect to  $t$ ) of the book.
  - Using the equation above, find the instantaneous velocity of the book at times  $t = 1, 2, 3, 4$ .

## **Part 2 – Create your Own Problem**

In this part of the task, you will create your own real-world problem involving free-fall and develop a set of questions that your classmates could answer to explore the situation. Explain the problem you are modeling, and then provide a numerical, algebraic, and graphical representation of your problem. In addition, provide 5-6 questions that students could answer to explore the position and velocity of the object in your problem, as well as the graphical representation and relationship to the derivative and the tangent line problem.

### **Reflection Questions**

1. Summarize what you have learned in this activity. Explain which representation of the position of the ball (numerical, graphical, algebraic) was the most useful to you and why.
2. How does the instantaneous velocity of the ball compare to the average velocity? How do each of these values give you a better understanding of the problem you are exploring?
3. How do the different representations used (graphical, numerical, algebraic, verbal) in this activity help you to understand the problem you are exploring?
4. How did the process of creating your own problem and developing your own questions for your classmates contribute to your understanding of the real-world problems being modeled?

## Scoring Rubric

CATEGORY	4 (Superior)	3 (Satisfactory)	2 (Approaching Satisfactory)	1 (Unsatisfactory)
<b>Conceptual Understanding</b>	The solutions presented and all components of the task demonstrate a deep understanding of the concepts of average and instantaneous rate of change, as well as the various representations used. Students apply a variety of mathematical concepts correctly and fully explain their solutions.	The solutions presented and all components of the task demonstrate a more than basic understanding of the concepts of average and instantaneous rate of change, as well as the various representations used. Students apply most mathematical concepts correctly and generally explain their solutions.	The solution presented is incomplete or contains errors that demonstrate an incomplete understanding of the key concepts.	There are no solutions provided or the solutions provided are completely incorrect or unconnected to the question being asked.
<b>Mathematical Reasoning and Problem Solving Strategies</b>	The student demonstrates the use of an effective and well-planned strategy for solving the problems. The strategy used is clearly explained and the reasoning and procedures used are correct and clear.	The student demonstrates the use of a sound strategy for solving the problems. The strategy used is mostly explained and the reasoning and procedures used are generally correct and clear.	The student demonstrates the use of a somewhat useful strategy that leads to an incomplete solution. The procedures and reasoning are not clearly explained.	The student does not demonstrate any evidence of a problem solving strategy and does not explain any reasoning.
<b>Explanation of Mathematics and Understanding (COMMUNICATION)</b>	The student provides a clear and comprehensive explanation for the problems solved. Correct mathematical language and notation is used and all steps in the process are explained clearly. The student provides a clear and understandable reflection at the end of the task.	The student provides a clear explanation for the problems solved. Correct mathematical language and notation is generally used and most steps in the process are explained clearly. The student provides a clear and understandable reflection at the end of the task.	The student provides an incomplete and/or unclear explanation for the problems solved. Correct mathematical language and notation is rarely used and few steps in the process are explained clearly. The student provides an incomplete reflection.	The student does not explain his or her solution and the steps provided are unclear. No reflection is provided.
<b>Creativity (IMAGINATION)</b>	The problem situation in part 2 is creative and shows imagination. It provides a novel way for students to explore the concepts of average and instantaneous velocity.	Most parts of the problem situation in part 2 are creative and show imagination.	Some creativity is shown in the problem situation in part 2.	The problem created shows little or no creativity or imagination.